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Article

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International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Hong, Cheng-Yih/Lee, Yi-Chain et. al. (2018). Agricultural sector input technical coefficients, demand changes and CO2 emissions after the financial crisis : environmental input-output growth factor model approach. In: International Journal of Energy Economics and Policy 8 (6), S. 339 - 345.
doi:10.32479/ijeep.7029.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2018, 8(6), 339-345.

Agricultural Sector Input Technical Coefficients, Demand Changes and CO_2 Emissions after the Financial Crisis: Environmental Input-Output Growth Factor Model Approach#

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Received: 10 August 2018 **Accepted:** 15 October 2018 **DOI:** https://doi.org/10.32479/ijeep.7029

ABSTRACT

The agricultural sector has been declining year by year with the proportion of economic growth and GDP. The financial crisis in 2007 caused huge losses in the world's economies. Taiwan cannot avoid economic damage. In the future, the way from agriculture to production needs to be transformed. This study uses the environmental input-output growth factor model to estimate the changes in CO_2 emissions in the agricultural sector before and after the financial crisis, and summarizes the changing factors to observe the development characteristics of the agricultural sector. The results show that there are differences in the influencing factors before and after the financial crisis. The biggest influencing factors are "domestic final demand" and "production input technical coefficients."

Keywords: Agricultural Sector, CO_2 Emission, Input Technical Coefficients, Environmental Input-output Growth Factor Model
JEL Classifications: Q15, C6, Q5

Provided funding from Poultry Industry Section Department of Animal Industry, Council of Agriculture Executive Yuan, Taiwan.

1. INTRODUCTION

The economic growth in Taiwan earlier days was mainly relying on the agriculture exporting sector. The growth ratio was then shared by the increasing development of industrial and service sector. The economic transformation of liberalization and globalization in the 1980' has led to the overall ratio of agriculture, industrial and service sector to be readjusted to 7.35%, 43.83% and 48.82% respectively in year 1981. In year 1988 the agriculture sector remained a decreasing trend while service sector has exceeded 50% and ever since then that primary sector continued to descend while tertiary sector gradually growing. The sector ratio in year 2016 has become 1.82%, 35.06% and 63.13% for agriculture sector, industrial sector and service sector respectively. Such numbers indicate the domestic economy in Taiwan has stepped into a slow growing stage and required further industrial upgrade and readjustment to achieve a more ideal growing ratio. However, the financial crisis in year 2008 has revealed the failure in industrial structure transformation, especially in the agriculture sector (Hong and Li, 2015).

Table 1 indicates the agriculture sector development after the financial crisis. The overall agriculture productivity in year 2007 was 389.1 billion dollars, which was mostly contributed by 168 billion dollars of agriculture goods and products. The rest of the productivity was contributed by livestock husbandry then followed by fishery and forestry. The overall productivity of agriculture sector increased to 517.57 billion dollars in year 2016. The productivity of farming and livestock husbandry also increased to 265.53 billion dollars and 165.38 billion dollars respectively. On the other hand, the productivity of fishery and forestry decreased during the same period.

Figure 1 reveals the structural changes in agriculture sector. The agriculture structure in year 2007 was mainly composed by agriculture products 43.27% and followed by livestock husbandry 32.04$, fishery 24.56% and forestry with only 0.13%. The agriculture structure to be the same order in the next 10 years. However, fishery reduced by 7.9% to be 16.7% in overall, while agriculture product raised 8.03% and livestock husbandry remained to be 31.95%. The data collection has provided us a better insight of the transaction in agriculture sector throughout the years.

Table 2 reveals the productivity changes of each agriculture sector since year 1976–2016. The table indicates only the average productivity index in livestock husbandry remained to be positive. The rest of the sector has shown negative production rate especially in forestry sector.

Table 1: The productivity of agriculture in Taiwan since 2007

Sector	Agriculture	Forestry	Livestock	Fishery	Total
2007	168,368.46	492.62	124,690.06	95,578.09	389,129.23
2008	179,108.00	445.11	146,104.20	91,843.19	417,500.51
2009	178,123.65	416.17	142,034.40	85,901.38	406,475.60
2010	188,678.05	390.06	145,299.95	92,499.03	426,867.10
2011	209,846.34	388.28	159,175.24	106,321.68	475,731.54
2012	222,634.08	374.94	148,454.30	106,174.29	477,637.60
2013	230,456.82	431.66	149,955.35	101,649.63	482,493.47
2014	246,981.58	381.61	168,632.70	104,961.64	520,957.53
2015	244,422.38	243.78	163,941.31	92,255.54	500,863.02
2016	265,529.21	206.71	165,384.02	86,452.60	517,572.53

Unit: Million dollars

Taiwan has joined WTO membership in year 2002 and provided new economic development opportunity together with upcoming challenge for agriculture sector from international market. Such challenge has changed the structure of tertiary industry. The agriculture policy has been adjusted in year 2016 to promote circular economy in order to further develop environmental friendly technology. The Taiwanese government has established "promotion of circular agriculture zone" to enhance future sustainable development direction by adopting the "resource sustainable and recyclable generation" production procedure. Such promotion policy requires knowledge of long term agriculture sector transition history to ensure the influence of agriculture development impact on relevant environment issues.

This research mainly focuses on the observation period regarding to the financial crisis during year 2006–2016. The purpose of this study is to analyze the influence of agriculture production technology and domestic demand changes on the CO_2 emission volume. This study shall serve as a reference to the future Taiwan agriculture sustainable development promotion policy from the aspect of agriculture impact on environmental issues.

This research used input-output growth factor model (I-OGFM) and Environmental I-OGFM (EI-OGFM) to analyze the factors promotes agriculture sector development and the corresponding CO_2 emission volume. The aim of this study is to reveal the influence of agriculture development transition on environmental issues.

2. LITERATURE REVIEW

With the development of the world economy, environmental issues have become the main concern of the world, mainly due to the increasing demand for energy, industrialization and climate change (Toshiyuki et al., 2017; Elias, 2017).

In the past, there have been many literatures on the production of gas emissions from agriculture during production (Mylan et al., 2015;

Figure 1: Agricultural industry structure change in Taiwan

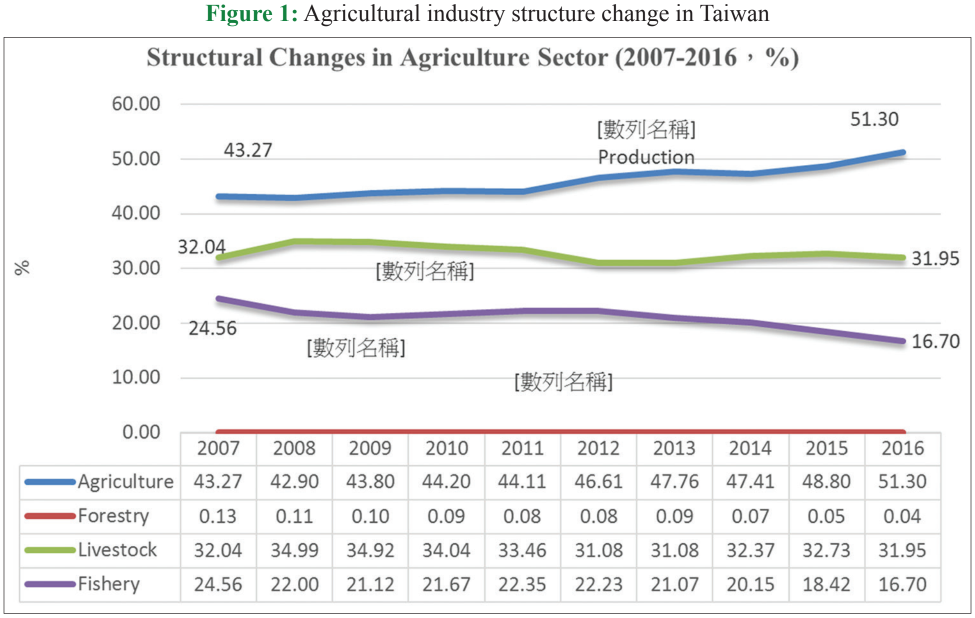

Table 2: Rate of change in production index

Sector	Agriculture	Forestry	Livestock	Fishery
1976	6.36	4.78	26.73	7.83
1981	−2.44	3.90	1.85	−3.87
1986	−5.19	10.80	3.37	6.03
1991	2.55	−6.36	8.95	−7.49
1996	−0.28	−17.62	4.04	−4.68
1997	1.60	12.48	−7.43	1.96
1998	−8.27	26.67	−7.39	0.11
1999	6.79	−15.96	−3.63	−2.08
2000	−4.68	−1.35	5.70	9.34
2001	−4.33	−17.20	0.31	1.68
2002	5.50	11.55	−1.87	8.13
2003	−2.65	8.90	−2.00	7.08
2004	−4.95	−0.18	−0.14	−7.12
2005	−9.49	−21.79	−2.94	−2.05
2006	9.44	11.37	2.56	−14.00
2007	−6.48	−31.48	−2.43	5.74
2008	−0.57	−7.49	−4.46	−13.61
2009	0.95	1.66	−0.39	−8.97
2010	2.69	−8.17	1.34	1.79
2011	6.18	−1.26	3.33	−1.41
2012	−4.13	3.60	−1.42	2.68
2013	−0.49	8.67	−1.95	−1.26
2014	3.21	−14.20	0.11	−0.11
2015	−4.56	−39.39	−0.57	−5.66
2016	−4.87	−20.36	1.89	−10.06
Average	−0.72	−3.94	0.94	−1.20

Unit: Percentage

Tokimatsu et al., 2015). Due to the gas emission factors of agricultural production, on the one hand, it will be affected by the uncertainty of the supply and demand of the market, and on the other hand, it will be affected by the level of production technology. Therefore, the research conclusions also show significant different results.

As with other industrial development processes, as the energy consumption of agricultural production increases rapidly, it brings benefits to farmers, but it also has an adverse impact on the environment (Ghorbani et al., 2011). In particular, agricultural production processes increase gas emissions through deteriorating water and land resources and lead to global warming (Nakagawa et al., 2007; Ozkan et al., 2007).

Many studies have pointed out that agriculture will cause an increase in CO2 emissions. However, when used and managed by agricultural land, CO2 and other greenhouse gas emissions will be reduced. Paustian et al. (1998) pointed out that agriculture can reduce CO2 emissions and bring other benefits, such as improved soil fertility, cost saving, and diversification of agricultural production.

Lin and Fei (2015) used the Malmquist index method to analyze the relationship between China's agricultural sector and carbon dioxide emissions, and argued that different CO2 emission policies should be adopted according to the actual situation in different regions. In addition, there are also literatures discussing CO2 emissions from different production sectors, such as Hendrickson et al. (1998). Hong et al. (2017) analyzed the impact of R&D investment on the economics of all industries and CO2 emissions.

Li and Geng (2013) and Chen et al. (2015) analyze the impact of climate change on Chinese agriculture and conclude that global warming is causing economic losses in China's agricultural sector. There are also research papers that determine the effects of greenhouse gas reduction by the potential of livestock manure biogas production, such as Karaca (2018).

3. EMPIRICAL MODELS

3.1. I-OGFM

In the framework of I-O model, the following balance equation can be derived (Fujita and William, 1997).

Industry (X_i) production equilibrium equation can be expressed by (1).

The physical quantity bought by sector j to sector i when j produces the commodity j is denoted x_{ij}. This condition can be expressed as:

$$x_{11}+x_{12}+x_{13}+\ldots+x_{1n}+F_1+E_1=X_1+M_1$$

$$x_{21}+x_{22}+x_{23}+\ldots+x_{2n}+F_2+E_2=X_2+M_2$$

$$\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots$$

$$x_{n1}+x_{n2}+x_{n3}+\ldots+x_{nn}+F_n+E_n=X_n+M_n \tag{1}$$

$$\sum_{j=1}^{n} x_{ij}+F_i+E_i=X_i+M_i\,(i=1,2,\cdots n) \tag{2}$$

If coefficients are defines in physical terms, it is assumed that $a_{ij}=\dfrac{x_{ij}}{X_j}$ for all i and j are stable.

Where F is the amount of the domestic final demand for industry ($n \times 1$). M represents the diagonal matrix of import coefficient ($n \times n$). I is the identity matrix ($n \times n$).

Where,

$$M_i=m_i\left(\sum\nolimits_{j=1}^{n} a_{ij}X_j+F_i+E_i\right),\ (i=1,2,\cdots n)$$

$$m_i=\frac{M_i}{\sum\nolimits_{j=1}^{n} a_{ij}X_j+F_i+E_i}\quad (i=1,2,\cdots n)$$

This studies must be at equilibrium by row and by columns. By rows the accounting identity (2) becomes $\sum\nolimits_{j=1}^{n} a_{ij}X_j+F_i+E_i=X_i+M_i$, that is:

$$X=[I-(I-M)A)]^{-1}\,[(I-M)F+E] \tag{3}$$

Where A is the input coefficient matrix ($n \times n$).

$$A \equiv \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix}$$

t represents the base period, t + 1 represents the current period, and following formula is used to calculate δX:

$$\delta X=X_{t+1}-X_t \tag{4}$$

and the quantity model (4) can be written as:

$$\delta X = \begin{array}{l}\left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}+E_{t+1}\right]- \\ \left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right]\end{array} \quad (5)$$

Denoting by $B_t\,B_{t+1}$ and $H_t\,H_{t+1}$ the following matrix and vector:

$$\left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}=B_{t+1},\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}=B_{t}$$

$$\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}+E_{t+1}\right]=H_{t+1},\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right]=H_{t}$$

and writing:

$$B_t+\delta B=B_{t+1} \quad (6)$$

At this stage it suffices to note that we may rearrange the second member of (6) as follows:

$$B_t\delta H+\delta B\delta H=B_{t+1}\delta H$$

$$\delta X=(B_t\delta H)+\delta BH_t+\delta B\delta H=B_t\delta H+\delta BH_t \quad (7)$$

Denoting by B^* the following matrix:

$$\left[I-\left(I-\bar{M}_{t}\right)A_{t+1}\right]^{-1}=B^*$$

$$\delta B=B_{t+1}-B_t \quad (8)$$

$$\begin{aligned}&=\left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}-\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}\\&=\left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}-\left[I-\left(I-\bar{M}_{t}\right)A_{t+1}\right]^{-1}+ \quad (9)\\&\left[I-\left(I-\bar{M}_{t}\right)A_{t+1}\right]^{-1}-\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}\\&=\left(B_{t+1}-B^*\right)+\left(B^*-B_t\right)\end{aligned}$$

Where,

$(B_{t+1}-B^*)$ indicates the effect of the change in the self-sufficiency rate under the constant input coefficient (A_{t+1}).

(B^*-B_t) indicates the effect of the change in the input coefficient (A) under the constant self-sufficiency rate $(I-\bar{M}_t)$.

Denoting by H^* the following vector:

$$\left[\left(I-\bar{M}_{t}\right)F_{t+1}+E_{t+1}\right]=H^*$$

and writing:

$$\delta H=H_{t+1}-H_t \quad (10)$$

$$\begin{aligned}&=\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}+E_{t+1}\right]-\left[\left(I-\bar{M}_{t}\right)F_{t+1}+E_{t+1}\right]+\\&\left[\left(I-\bar{M}_{t}\right)F_{t+1}+E_{t+1}\right]-\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right] \quad (11)\\&=\left(H_{t+1}-H^*\right)+\left(H^*-H_t\right)\end{aligned}$$

Where,

$(H_{t+1}$-$H^*)$ indicates the effect of industrial self-sufficiency rate $(I-\bar{M}_t)$ when domestic final demand (F_{t+1}) and export (E_{t+1}) are fixed.

A indicates the effect of changes in final demand and export under fixed self-sufficiency rate.

$(H^*$-$H_t)$ indicates that the self-sufficiency rate $(I-\bar{M}_t)$ is fixed, and the effect of the change of domestic final demand and export.

and writing:

$$\delta X=Bt[(H_{t+1}-H^*)+(H^*-H_t)]+[(B_{t+1}-B^*)+(B^*-B_t)]$$
$$Ht+(B_{t+1}-B^*)+(B^*-B_t)[((H_{t+1})-H^*)+(H^*-H_t)] \quad (12)$$

We see that (6) can be decomposed as follows:

$$\delta X = \begin{array}{l}B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}-\left(I-\bar{M}_{t+1}\right)F_t\right]+\\ B_{t+1}\left(E_{t+1}-E_t\right)+B_{t+1}\begin{bmatrix}\left(I-\bar{M}_{t+1}\right)F_t-\\ \left(I-\bar{M}_{t}\right)F_t\end{bmatrix}+\\ \left(B_{t+1}-B^*\right)\left[\left(I-\bar{M}_{t}\right)F_t+E_t\right]+\\ (B^*-B_t)[(I-M?_t)F_t+E_t]\end{array} \quad (13)$$

3.2. EI-OGFM

Pol_t and Pol_{t+1} represent CO_2 emissions in t years and t+1 years.

$$Pol_t=\hat{E}_tX_t=\hat{E}_t\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right] \quad (14)$$

$$Pol_{t+1}=\begin{array}{l}\hat{E}_{t+1}X_{t+1}=\left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}\\ \left[\left(I-\bar{M}_{t+1}\right)F_{t+1}+E_{t+1}\right]\end{array} \quad (15)$$

$$Pol_{t+1}-Pol_t=\delta Pol \quad (16)$$

Where the emissions coefficient $e_j={CO_{2j}}/{x_j}$, and $\hat{E}$ is the diagonal matrix of the elements of the emissions coefficients for various industries.

$$\hat{E}=\begin{pmatrix}e_1 & \cdots & 0\\ \vdots & \ddots & \vdots\\ 0 & \cdots & e_n\end{pmatrix}$$

We use (13) and (16) to write

$$\delta Pol = \begin{array}{l}\hat{E}_{t+1}B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}-\left(I-\bar{M}_{t+1}\right)F_t\right]\ (a),+\\ \hat{E}_{t+1}B_{t+1}\left(E_{t+1}-E_t\right)(b)+\hat{E}_{t+1}B_{t+1}\begin{bmatrix}\left(I-\bar{M}_{t+1}\right)F_t-\\ \left(I-\bar{M}_{t}\right)F_t\end{bmatrix}(c)+\\ \hat{E}_{t+1}\left(B_{t+1}-B^*\right)\left[\left(I-\bar{M}_{t}\right)F_t+E_t\right](d)+\\ \left(\hat{E}_{t+1}B^*-\hat{E}_tB_t\right)\left[\left(I-\bar{M}_{t}\right)F_t+E_t\right](e)\end{array}$$

Each of these terms measures the effects of a particular source of CO_2 emissions growth:

a. The first term, the CO_2 emissions effects of changes in domestic final demand;
b. The second term, the CO_2 emissions effects of changes in exports;
c. The third term, the CO_2 emissions effects of changes in final import coefficients;
d. The fourth term, the CO_2 emissions effects of changes in self-sufficiency coefficients;
e. The fifth term, the CO_2 emissions effects of changes in production input technical coefficients.

4. EMPIRICAL RESULTS

In September 2007, the financial crisis caused serious economic decline to Taiwan, the most damage of which was the decrease in exports and the increase in unemployment rate (Hong and Li, 2015). The economic impact of the financial crisis so far has not completely stopped. The agricultural sector is also affected. This section divides the impact of the financial crisis into two phases, the early financial crisis period (2006–2011) and the late financial crisis period (2011–2016). The research model uses I-OGFM to calculate production changes in the agricultural sector, and EI-OGFM estimates changes in CO_2 emissions. The following is the empirical analysis result of this paper.

4.1. The Agricultural Growth in the Early Financial Crisis Period

In the early stages of the financial crisis, the agricultural sector decreased by around NT$ 95.280 billion dollars, with the largest decline in agricultural production, followed by livestock products, which decreased by NT$ 72.533 billion dollars and NT$ 32.20 billion dollars, respectively. During this period only fishery products showed positive growth are summarized in Table 3.

The change factor in the agricultural sector was the most effective with “domestic final demand” increased by NT$ 119.68 billion dollars, and the second growth factor is NT$ 28.15 billion dollars for “exports.” “Domestic final demand” and “exports” led the growth of the agricultural sector, with an increase of NT$ 58.85 billion dollars in agricultural production and NT$ 46.89 billion dollars in Livestock products.

On the other hand, the other three factors have caused a negative impact. The “production input technical” factors have the greatest impact, and the damage scale is NT$ 212.20 billion dollars.

4.2. The Agricultural Sector Change Factors in the Late Financial Crisis Period

The most serious period of the financial crisis was from 2009 to 2010. After many countries including Taiwan implemented policy responses, the economy became more stable and the agricultural sector gradually resumed growth. As shown in Table 4, the agricultural sector production has increased significantly compared to the early stages of the financial crisis.

In the late financial crisis period, except for the negative growth of fishery products (-NT$ 37.84 billion dollars), other agricultural sectors showed positive growth, and the overall agricultural sector increased NT$ 451.53 billion dollars. From the empirical results, it is found that the development of the agricultural sector in the early and late stages of the financial crisis showed different results. Among the growth factors of the agricultural sector, the contribution of “domestic final demand” is the largest (NT$ 310.17 billion dollars), and other factors have a positive impact on agricultural development. The most notable of these is that the contribution of “production input technical coefficients” factors to the agricultural sector has shifted from negative to positive, increasing NT$43.97 billion dollars. This means that the financial crisis promotes the improvement of production technology in the agricultural sector and enhances agricultural competitiveness.

4.3. CO_2 Emission Change Factors in the Early Financial Crisis Period

The CO_2 emission of the agricultural sector is affected by the amount of production, and the economic impact of the financial crisis affects the demand for agriculture.

This section will analyze the changes in the CO_2 emissions of the agricultural sector after the financial crisis, and compare the differences between the early and late stages of the financial crisis.

As shown in Table 5. During the initial period of the financial crisis, the agricultural sector was also damaged. The reduction in demand for agricultural products reduced CO_2 emissions by 369,808 tons, of which 237,183 tons were reduced by agricultural production CO_2 emission, followed by Livestock products with 140,098 tons. Fishery products increased CO_2 emissions by 8,455 tons. Enterprises were affected by the financial crisis and reduced their investment. Due to “production input technical coefficients” factors, CO_2 emission was reduced by 369,808 tons. In addition, the “final import” and “self-sufficiency coefficients” factors also reduced the CO_2 emission of the agricultural sector by 6,733 tons and 45,167 tons, respectively.

4.4. CO_2 Emission Change Factors in the Late Financial Crisis Period

As shown in Table 6. In the later period of the financial crisis, the economic situation gradually stabilized and the demand for agricultural products increased. As a result, the CO_2 emissions in the agricultural sector have also changed. During the period 2011–2016, CO_2 emissions increased by 563,296 tons in all agricultural sectors, and 561,685 tons in agricultural production CO_2 emissions accounted for the most.

The change factor of CO_2 emissions during this period is mainly due to the increase of “domestic final demand,” and the second factor is the result of the increase of “self-sufficiency coefficients.” The increase in “self-sufficiency coefficients” contributes to economic growth and the increase in employment, but industrial upgrading to increase production efficiency can reduce CO_2 emissions to improve the environment.

Comparing the changes of CO_2 emissions coefficient (ton/million) between 2006-2011 and 2011-2016, the effect of the changes in production input technical coefficients is most obvious. The CO_2

Table 3: Agricultural sector change factors (2006–2011)

Sector	Effects of changes in domestic final demand	Effects of changes in exports	Effects of changes in final import	Effects of changes in self-sufficiency coefficients	Effects of changes in production input technical coefficients	Total
Agricultural production	58,850	14,270	−8,153	−20,800	−116,700	−72,533
Livestock products	46,890	10,120	787	−3,000	−87,000	−32,203
Forest products	130	360	−82	−2,900	1,200	−1,292
Fishery products	13,810	3,400	3,438	−200	−9,700	10,748
Total	119,680	28,150	−4010	−26,900	−212,200	−95,280

Unit: NT$ million

Table 4: Agricultural sector change factors (2011–2016)

Sector	Effects of changes in domestic final demand	Effects of changes in exports	Effects of changes in final import	Effects of changes in self-sufficiency coefficients	Effects of changes in production input technical coefficients	Total
Agricultural production	359,856	6,319	18,398	62,707	9,348	456,626
Livestock products	7,167	−2,638	3,067	8,752	15,146	31,493
Forest products	2,314	521	82	51	−1,719	1,249
Fishery products	−59,171	2,577	−1,235	−1206	21,197	−37,839
Total	310,166	6,779	20,312	70,304	43,972	451,529

Unit: NT$ million

Table 5: Agricultural sector CO_2 emission factors (2006–2011)

Sector	Effects of changes in domestic final demand	Effects of changes in exports	Effects of changes in final import	Effects of changes in self-sufficiency coefficients	Effects of changes in production input technical coefficients	Total
Agricultural production	98,814	23,961	−13,690	−34,925	−311,343	−237,183
Livestock products	78,732	16,992	1,321	−5,037	−232,107	−140,098
Forest products	218	604	−138	−4,869	3,201	−983
Fishery products	23,188	5,709	5,773	−336	−25,879	8,455
Total	200,953	47,266	−6,733	−45,167	−566,126	−369,808

Unit: Tons

Table 6: Agricultural sector CO_2 emission factors (2011–2016)

Sector	Effects of changes in domestic final demand	Effects of changes in exports	Effects of changes in final import	Effects of changes in self-sufficiency coefficients	Effects of changes in production input technical coefficients	Total
Agricultural production	440,978	7,743	22,545	76,843	13,576	561,685
Livestock products	8,783	−3,233	3,758	10,725	21,996	42,029
Forest products	2,836	638	100	62	−2,496	1,140
Fishery products	−72,510	3,158	−1,513	−1,478	30,783	−41,560
Total	380,086	8,307	24,891	86,153	63,859	563,296

Unit: Tons.

emissions coefficient decreases from 2.67 (ton/million) to 1.45 (ton/million), the other four factors fell from 1.70 (ton/million) to 1.23 (ton/million). After three years of the financial crisis, Taiwan invested in agricultural equipment and upgraded production technology to reduce CO_2 emissions.

5. CONCLUDING REMARKS

In 2007, a world-scale financial crisis occurred. Taiwan economy suffered severe damage, and the export recession and the rapid increase in the unemployment rate highlighted the seriousness of the imbalance in the economic structure. After the Second World War, Taiwan experienced a period of high economic growth and also suffered a lot of environmental damage. How to develop a sustainable economic model is the future trend, and the agricultural sector is also a part of it. However, the development of sustainable agriculture has the necessary observation of past development models, especially the understanding of the state of agricultural development after the financial crisis. This paper uses I-OGFM and EI-OGFM to analyze the growth of the agricultural sector and the changing factors of CO_2 emissions, and summarizes the following points.

1. In the early period of the financial crisis (20062011), Agricultural production suffered the greatest loss. The loss of 72.53 billion dollars was equivalent to 76.13% of the total loss of the agricultural sector. The main factor was the "production input technical coefficients," which indicated that the production technology in the agricultural sector was inefficient.
2. In the later period of the financial crisis (2011–2016), the market gradually recovered the demand for the agricultural

sector, and the agricultural output value increased by 451.53 billion dollars. The main factor for the increase was "domestic final demand," which accounted for 68.69% of the total increase. This means that the growth of Taiwan's agricultural sector needs to rely on the support of the domestic market, which is different from the development model of other export industries.

3. Comparing the CO2 emissions before and after the financial crisis, the empirical results are known. The impact of the economy at the beginning of the financial crisis was greater, and CO2 emissions were reduced due to reduced demand in the agricultural sector. Among them, Agricultural production declined the most, accounting for 64.14% of the total CO2 emissions of all agricultural sectors. The main factor in the reduction of CO2 emissions is "production input technical coefficients."

By the end of the financial crisis, the impact on the economy has slowed down, and the market demand for agricultural products has gradually improved. More CO_2 emissions are also produced in the production process due to increased consumption in the agricultural sector. The agricultural sector that produces the most CO_2 emissions is Agricultural production, mainly due to "domestic final demand," accounting for 67.48% of the gas emissions in this sector.

However, in the past, Taiwanese companies often used the growth model of cost reduction to ignore the damage caused by CO_2 emissions, and also hindered the upgrading pressure of Taiwan's industry, resulting in slow technological upgrading.

In recent years, Taiwan has promoted a production model of circular economy. In this way, it is used as a development model for upgrading technology and environmental protection. For example, in the agricultural sector, the «Promotion of circular agriculture zone» approach was established. In other words, this is a sustainable development that promotes both agriculture and the environment with the "sustainable resource recovery and recycling."

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